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ABSTRACT

An emerging focus of elementary and secondary mathematics instruction is on problem solving. This study examined an instructional approach for teaching children with learning disabilities how to solve arithmetic word problems. The study was conducted with 60 fifth and sixth grade students who had previously been identified as learning disabled. The experimental group was taught using an instructional design which involved the teaching of problem solving steps and the use of "prompts" to help students think through the problem. Both the experimental group and the control were permitted the use of calculators. Results indicated that students in the experimental group outperformed the control group. Implications of the study are discussed, stressing that learning disabled students who have exhibited very poor arithmetic word problem solving skills can be taught to be proficient problem solvers. An example of a prompt outline card used with the experimental group is included. (TW)

An Arithmetic Verbal Problem Solving Model for Learning Disabled Students

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Abstract

This study examined an instructional approach for teaching children with learning disabilities how to solve arithmetic word problems. The theoretical framework and intervention strategy were derived from a problem solving model designed by Margaret Nuzum. Her model was based on information processing, cognitive behavior modification, and mastery learning. Although retaining many of the components of Nuzum's original instructional plan, this study used expanded instructional materials and calculators as integral parts of a new plan. The study was conducted with 60 fifth and sixth grade students with learning disabilities in New York City public school Resource Rooms. A pretest, posttest, control group design was used. Results on a posttest measure showed that on every problem type (addition, subtraction, and two-step problems as well as problems with extraneous information) students in the experimental condition who were taught a specific instructional plan and permitted calculator use in addition to being given sufficient practice for mastery, outperformed those in the control group. Calculator use plus extended practice without the instructional plan did not improve the problem solving performance of students in the control group.

The National Council of Teachers of Mathematics has recommended that the school mathematics curriculum for the 1980's be organized around problem solving. Recent appeals for a greater focus on verbal problem solving within mathematics instruction have rarely prompted the results they called for. Students' performance on verbal problem solving tasks ranks far below their computation performance. Despite all the attention to the topic, little empirical data has been collected on the most effective strategies for teaching problem solving.

Most of the research in problem solving has been conducted with the average student. There has been little study of the particular problem solving characteristics of the learning disabled. There has also been a dearth of information on methods of improving problem solving performance of the learning disabled. This study examined the effectiveness of a systematic word problem solving plan coupled with calculator use on the performance of 30 learning disabled 5th and 6th grade students in New York City Resource Room programs.

Theoretical Framework

The model used in this study was influenced by research in cognitive

behavior modification (Meichenbaum, 1977), mastery learning (Block, 1971: Bloom, 1976), and the calculator as an integral tool for problem solving (Suydam, 1980; 1982). The plan was an adaptation and expansion of Margaret Nuzum's curriculum model (Nuzum, 1983) which itself was based on the information processing paradigm (Newell & Simon, 1972). Results of the research by Zweng, Garaghty, and Turner (1979) which pinpointed effective strategies for verbal problem solving instruction were also integrated into this plan. In particular, the strategies adapted from Zweng et al included focusing the student's attention on:

- the action implied in the problem (objects put together, removed, separated, etc.
- the part-part-whole relationship of the quantitites within the problem
- the size of the answer (picking the largest number in the problem and determining whether that number would get larger or smaller; then asking what mathematical operation would yield a larger or smaller number)

Method

<u>Subjects</u>: All students who participated in the study were classified as learning disabled as per New York City regulations, and all worked in a Resource Room for one or two periods per day five days a week. The rest of their time was spent in regular fifth and sixth grade classes. Of the sixty students who participated in the study, more than 90% were Black or Hispanic. All students were proficient in English. According to their Committee on the Handicapped evaluations, all were of average intelligence.

Students were divided into an experimental and a control group with 30 students in each. The two groups did not differ significantly with respect to sex, grade, or age.

All students were given the individually administered Keymath computation and word problems subtests. The results of these tests clearly showed that the students in both groups had average or above average skills in computation (scores were within four months of the student's actual grade in school; some of the mean scores were markedly above average - in some cases more than two years above grade level).

This picture of competence changed dramatically, however, when one looked at the word problems subtest. On the average, fifth and sixth graders in the experimental group scored about three years <u>below</u> grade level on this subtest. In the control group, fifth graders had mean scores about two and one-half years below grade level, and sixth graders were more than three years below their expected performance level in word problem solving. There was no significant difference between the experimental and control groups on other measures of achievement (scores on the California Achievement Test in Reading and Stanford Diagnostic Math Test were also examined).

Students were considered eligible for word problem solving instruction after they had been recommended by their Resource Room teachers as being in need of that type of direct instruction. In addition, only those students who were performing within the average range (no more than four months below grade level on the Keymath Test) in computation but markedly below grade level (more than one year below grade expectation on the Keymath Test) in arithmetic word problem solving were selected for admission into the study. All students were

administered a problem solving pretest containing simple addition and subtraction problems, extraneous information and two-step problems. Computation ability was measured by presenting computation problems not embedded in word problems. Students in the study scored below 66% on the word problem solving pretest and above 90% on the computation test.

Schools were randomly assigned to either the control or experimental group. Random assignment of individuals was not possible because of administrative constraints.

Instructional Materials: An adapted and greatly expanded form of Nuzum's script and prompt cards were used with each child. Figure 1 shows an example of one of the prompt cards. Nuzum's word problem worksheets were also used as an instructional component. Only one-step addition and subtraction problems, problems with extraneous information, and two-step addition/subtraction problems were included on the worksheets. Each student was also supplied with a simple four function hand-held calculator.

Procedure: Direct instruction occurred in 30 minute segments twice a week for approximately six weeks or until the experimental group had

reached mastery on all four problem types. An adaptation and expansion of Nuzum's systematic instruction using a script and prompt cards was given to the experimental group. The instructional procedure was designed to make explicit the steps taken in solving problems. Students were encouraged to internalize the steps for solution as soon as they could but were permitted to use the prompt cards whenever necessary. Supplementary questions were included in the script for teachers to use with students experiencing difficulty solving the problems. Both experimental and control groups used calculators to assist their computation following a brief initial period of instruction and practice. Three problems of the type necessary for each teaching phase were included on worksheets.

Instructional sessions for the experimental group included:

1) distribution of necessary tools (calculators, highlighters, pencils)

2) verbal explanations by the teacher of the skill to be mastered

3) teacher modeling of the steps to the solution process using an outline or "prompt" card and script

4) student solving one problem out loud from a worksheet containing

three examples

5) other students and/or teacher offering prompts to the student solving the problem as needed (suggested prompts available from script developed for the program)

6) students solving set of three problems independently (whispering prompts if necessary)

7) process repeated until mastery (correct solution of 3 out of 3 problems) is reached

Instructional sessions for the experimental group included:

1) distribution of calculator and worksheets

2) teacher informing students that they would be doing practice to help them improve their performance in solving word problems

3) students working on comparable number of worksheets which experimental group needed to reach mastery on each problem type

4) teachers giving students immediate feedback on their performance re which problems were correct or incorrect

Data Analysis

After instruction was completed during the six week intervention,

students in both the experimental and control groups were given an alternate form of the problem solving test which had been administered as a pretest. An analysis of covariance was used to analyze data.

Results and Discussion

The results of the study indicated that the experimental group, which was given direct instruction in arithmetic verbal problem solving plus calculator use performed significantly better than the control group which was given a calculator and opportunity to practice solving word problems but no systematic instructional plan. The mean score for the experimental group was significantly higher ($p < .001$) than the corresponding mean for the control group across all four problem types. Table 1 shows the means and standard deviations for all four problem types (six examples of each type were given to both the experimental and control groups).

Scores improved dramatically. All the students in the problem solving study had scored at or below 56% on the pretest instrument. Posttest scores for students in the experimental group (with one exception) were in excess of 90%. The only student who did not score within this high range was reclassified as educable mentally retarded and

placed in a full-time special education class at the end of the school year. Yet even she more than tripled her initial problem solving score from pretest to posttest. Experimental group students did not demonstrate the performance decrements on two-step problems and problems with extraneous information which are often found in learning disabled students. They did, however, require many more trials to mastery for these two problem types. There was virtually no difference between pretest and posttest performance for the control group.

Characteristics of poor problem solvers which had been previously identified by Krutetskii (1976) among others were in evidence in this study. Before intervention occurred, students were observed to be very haphazard in their approach to solving arithmetic word problems and did not appear to perceive any similarities among problem types. The practice of scanning the problem for numbers and selecting an arbitrary operation (usually addition) was in evidence throughout the control group's term of involvement. The experimental group also performed in this manner on the pretest. By the time the experimental group took the posttest, however, they were able to categorize problems and correctly solve them according

to their common structure.

Implications

The primary contribution of this study lies in the demonstration that learning disabled children who have exhibited very poor arithmetic word problem solving skills can be taught to be proficient problem solvers. They can be taught to be more analytical in their problem solving performance and can learn to differentiate between several different problem types. With this problem solving model, educators can begin to explore the development of a variety of comprehensive problem solving programs for children with learning disabilities and examine the task variables that contribute to problem solving success within this group.

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Figure 1

OUTLINE CARD 3

READ (the whole problem)

ASK YOURSELF What is the question? Highlight it.

REREAD What is the highlighted question?
Reread the rest of the problem.

THINK What information do I need to answer the highlighted question?
Underline the label. Write it down.
Do I need all the information?
No? Cross out any numbers I don't need.
Yes? Continue.

What is the largest number? Circle it. Write it down.
Circle the other number in the problem.
Write it down under the largest number.
According to the question, what will happen to the largest number in the problem?
Will it get larger or smaller as the answer?
Larger? ADD Smaller? SUBTRACT

SOLVE

CHECK

Table 1

MEANS AND STANDARD DEVIATIONS FOR FOUR PROBLEM TYPES

Experimental Group n=30

PROBLEM TYPE	PRE $\bar{X}$	PRE SD	POST $\bar{X}$	POST SD
Addition	4.53	1.01	5.97	0.18
Subtraction	2.87	1.81	5.93	0.37
Two-Step	1.30	1.37	5.87	0.43
Extraneous Info.	1.53	1.38	5.03	1.35

Control Group n=30

PROBLEM TYPE	PRE $\bar{X}$	PRE SD	POST $\bar{X}$	POST SD
Addition	4.07	0.94	4.93	1.20
Subtraction	3.33	2.02	3.50	1.63
Two-Step	1.47	1.46	2.07	2.05
Extraneous Info.	1.10	1.12	1.80	1.61